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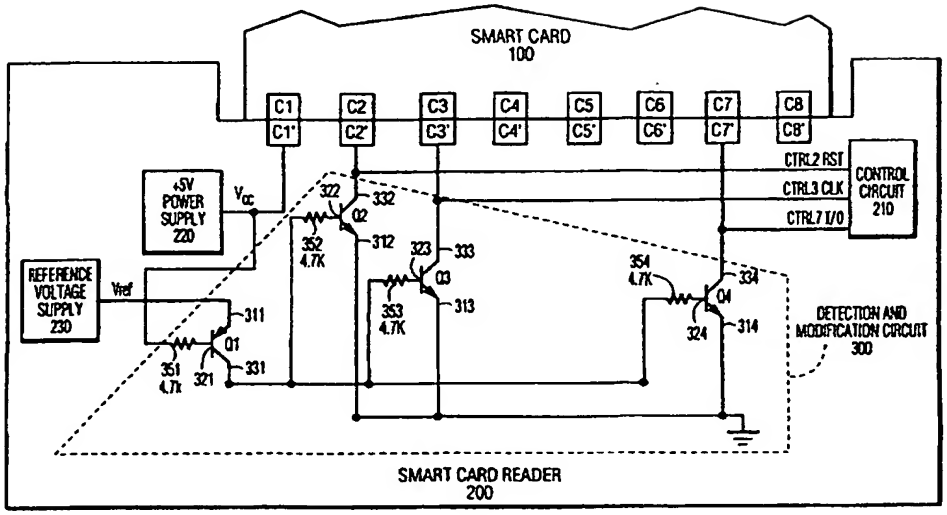

(57) Abstract

A circuit is provided to detect when a variation in a power supply provided to a smart card has occurred, indicating a possible fault in the smart card. As an example, the circuit detects this variation by determining when the power supply has dropped below a reference voltage. If this happens, the circuit will modify the smart card control signals, for example, by clamping them at or near ground potential, thereby preventing any possible damage to either the smart card or the smart card reader.

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FAULT DETECTION AND MODIFICATION CIRCUIT

The present invention relates generally to access control systems including an integrated circuit (IC) card, or "smart" card, for limiting access to information in signal processing application. More particularly, the present invention relates to a smart card reader operation when a fault is detected.

Systems such as pay-TV systems include access control sub-systems that limit access to certain programs or channels. Only users who are entitled (e.g., paid a fee) are permitted to view the programs.

Access control systems may include an integrated circuit (IC) card, or "smart" card, feature. A smart card is a plastic card the size of a credit card that has a signal processing IC embedded in the plastic. A smart card is inserted into a smart card reader that couples signals to and from the IC in the card. The IC in a smart card processes data such as security control information as part of an access control protocol. The IC includes a control microcomputer, such as the 6805 processor from Motorola Semiconductor, Austin, Texas, which includes ROM, EEPROM, and RAM memory. The processor performs various security control functions including entitlement management and generating a key for descrambling the scrambled data component of the signal.

Sometimes, the various contacts on the smart card may be shorted together by debris or by malfunctioning of the smart card circuitries. For example, debris can accumulate on the contacts of a smart card during manufacturing, shipment, user replacement or wiping action of the smart card. This shorting of the smart card contacts will, in turn, short the smart card power supply or present a low impedance to the power supply, causing it to go into a current limiting condition. If the signals to the card are not turned off or modified immediately, large current from the control lines could be coupled into the smart card, causing destruction. This may damage the circuitries in both the smart card and the smart card reader.

In accordance with an aspect of the present invention, a circuit is provided to detect when a variation in a power supply coupled to a smart card reader has occurred, indicating a possible fault in the smart card

(e.g., shorted contacts or other malfunctions). As an example, the circuit detects this variation by comparing the voltage coupled to smart card with a reference voltage. If the circuit detects that the voltage has dropped below the reference voltage, it will modify the smart card control signals, for example, by clamping them at or near ground potential. This prevents any potential damage to either the smart card or the smart card reader.

The invention may be better understood by referring to the accompanying drawing in which:

Figure 1A shows the physical layout of the contacts of an exemplary smart card as defined by the current ISO standard 7816.

Figure 1B shows the contact and signal assignments of an exemplary smart card as defined by the current ISO standard 7816.

Figure 2 shows an exemplary embodiment of the current invention as employed in a smart card reader.

Figure 3 shows another embodiment of the present invention using Field Effective Transistors (FETs).

Figure 4 shows another embodiment of the present invention using transmission gates to isolate the control lines to the smart card.

International Standards Organization (ISO) standard 7816 establishes specifications for a smart card interface. In particular, the ISO standard 7816-2 specifies that the electrical interface to the card will be via eight contacts positioned on the card surface as shown in Figure 1A. Six of the eight signals at the contact points are defined as Vcc (supply voltage), RST (reset signal), CLK (clock signal), GND (ground), Vpp (programming voltage for programming memory in the card IC), and I/O (serial data input/output). Two contacts are reserved for future use. The assignment of the signals to the smart card contacts is shown in Figure 1B.

Figure 2 shows an exemplary embodiment of the present invention. An ISO 7816 compliant smart card 100 having eight contacts C1 - C8 is shown coupled to and communicating with a smart card reader 200.

Again, the definitions and assignments of the contacts C1 - C8 of the smart card 100 are shown in Fig. 1B.

The smart card reader 200 illustrated in Fig. 2 also has eight contacts C1' - C8', which have the same assignments and definitions as shown in Fig. 1B. In particular, contact C1' of the smart card reader 200 is the Vcc contact for providing a power supply voltage to the smart card. In the present exemplary embodiment, the power supply is a regulated +5 V supply 220.

In addition, contacts C2', C3' and C7' are presented with respective control signals RST, CLK and I/O data from a control circuit 210. These control signals pass to or from the contacts via control lines CTRL2, CTRL3, and CTRL7. The control circuit 210 under the supervision of a microprocessor (not shown) selectively provides the proper signals to the smart card, according to the desired application and design requirements. For example, when necessary, the microprocessor may command the control circuit 210 to send a reset signal RST through the control line CTRL2 to contact C2'. This would allow the smart card 100 to be reset. Note that although only three control lines are shown in Fig. 2 for illustrative purposes, one skilled in the art can readily appreciate that additional control lines may be similarly utilized in the future for conducting signals to or from the smart card 100.

The detection and modification circuit 300 of the present invention comprises a detection transistor Q1. Q1 in the present embodiment is a PNP bipolar transistor such as a 2N3906 transistor made by Motorola. The emitter terminal 311 of Q1 is connected to a reference voltage supply 230. In this embodiment, the reference voltage is pre-calibrated to have the same potential as the Vcc supply voltage, +5v. The base terminal 321 of Q1 is connected to one end of a 4.7 KOhm base resistor, 351. The other end of the resistor 351 is connect to the output Vcc of the power supply 220. This allows detection transistor Q1 to monitor the power supply 220 as will be made clear later.

Each of the control lines CTRL2, CTRL3, and CTRL7 is connected respectively to one of the collector terminals 332-334 of clamping transistors Q2, Q3 and Q4. The clamping transistors Q2, Q3, and Q4 in the present embodiment are NPN bipolar transistors such as model BC546B

made by Motorola. Each of the base terminals 322-324 of the clamping transistors Q2-Q4 are each coupled to one end of a 4.7 KOhm resistor 352-353. The other ends of the resistors 352-353 are connected to the collector terminal 331 of the detection transistor Q1. All of the emitter terminals of Q2-Q4 are grounded.

The function of the detection and shut down circuit 300 will now be described. The function of the detection portion of the circuit 300 is to detect a variation of the supply voltage Vcc. It has been recognized by the inventor that when a short or current limiting condition exists in the power supply of the smart card reader, the output voltage will vary. In particular, the output will drop below the normally intended Vcc (i.e., +5V in our embodiment). Q1, in our example, is constantly monitoring the Vcc output at its base terminal 321. When the voltage output Vcc drops more than .6 volt below the preselected reference voltage, transistor Q1 will turn on.

Once transistor Q1 turns on, current also flows through the base terminals 322-324 of clamping transistors Q2-Q4 in the modification portion of the circuit 300. This will in turn cause each of the clamping transistors Q2-Q4 to turn on, thereby clamping the control lines CTRL2, CTRL3 and CTRL7 to be at or near ground potential (i.e., Vce saturation voltage, typically at .005 - .2 v). This modifies the voltages on the control lines and effectively shut them down, thus preventing any potential damage to any circuitries in either the smart card or the smart card reader.

Fig. 3 shows another embodiment of the present invention. In this embodiment, the detection and modification circuit 300 comprises Field Effective Transistors (FETs), instead of bipolar transistors. This embodiment is especially advantageous if circuit 300 is implemented as a part of an Integrated Circuit (IC). In addition, the reference voltage supply 231' shown in Fig. 3 is now variably adjustable. This allows an user to adjust, depending on the design requirements, the reference voltage at which the detection transistor Q1 and the clamping transistors Q2-Q4 will be turned on.

Fig. 4 shows another embodiment of the present invention. In this embodiment, the modification portion of the circuit 300 comprises

transmission gates G1-G3. These transmission gates G1-3 are controlled by detection transistor Q1. When Q1 detects that the power supply 220 drops below a reference voltage Vref, Q1 will cause the transmission gates G1-G3, to isolate the control signals from the contacts C2', C3' and C7'.

It will be apparent to those skilled in the art, that although the invention has been described in terms of specific examples, modifications and changes may be made to the disclosed embodiments without departing from the essence of the invention. For example, although the present invention is described mainly using ISO complaint embodiments, it can clearly be employed in any smart card related systems, include a non-standard system. It is, therefore, to be understood, that the appended claims are intended to cover all modifications which naturally flow from the foregoing treatise and examples.

CLAIMS

1. A smart card reader, comprising:

means for coupling a control signal to a smart card;

means for detecting a variation in a supply voltage provided to said smart card;

means, coupled to said coupling means, for modifying said control signal in response to said detection of said variation in said supply voltage.

2. The apparatus of claim 1, wherein said detecting means further comprises means for comparing said supply voltage with a reference voltage.

3. The apparatus of claim 2, wherein said comparing means further comprises a circuit for determining when said supply voltage drops below said reference voltage.

4. The apparatus of claim 1, wherein said modifying means clamps said control signal to ground potential.

5. A circuit for protecting a smart card, comprising:

a detection circuit, coupled to a supply voltage provided to said smart card, for detecting a variation in said supply voltage;

a modification circuit coupled to a control signal provided to said smart card for modifying said control signal in response to said detection of said variation in said supply voltage.

6. The circuit of claim 5, wherein said variation is detected by said detection circuit when said supply voltage drops below a reference voltage.

7. The apparatus of claim 6, wherein said detection circuit comprises a transistor.

8. The apparatus of claim 5, wherein said modification circuit clamps said control signal to ground potential.

9. A method of protecting a smart card, comprising:

detecting when there is a variation in a power supply provided to said smart card;

modifying a control signal provided to said smart card in response to said detection.

10. The method of claim 9, said detecting step further comprising:

comparing said power supply with a reference voltage supply to determine when said power supply drops below a reference voltage.

11. The apparatus of claim 1, wherein said modifying means isolates said control signal from said coupling means.

12. The apparatus of claim 5, wherein said modification circuit isolates said control signal from said smart card.

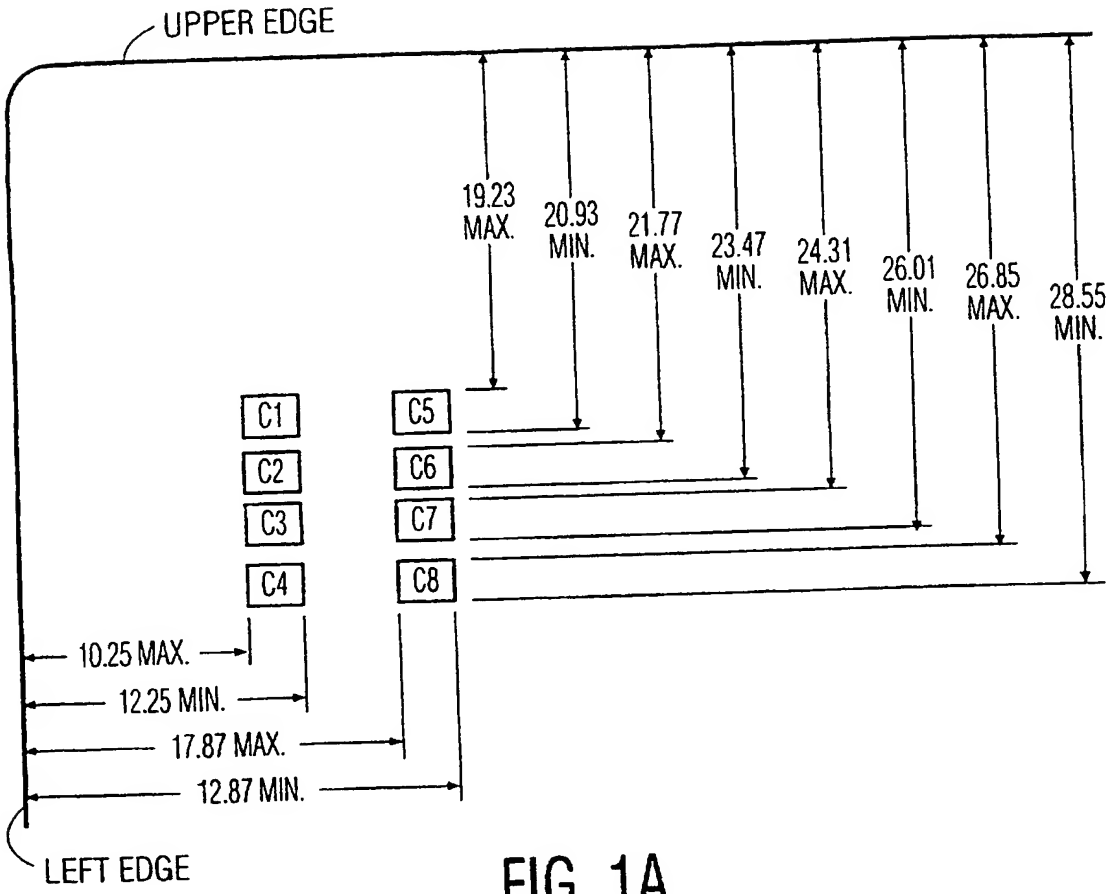

FIG. 1A

CONTACT NO.	ASSIGNMENT	CONTACT NO.	ASSIGNMENT
C1	VCC (SUPPLY VOLTAGE)	C5	GND (GROUND)
C2	RST (RESET SIGNAL)	C6	VPP (PROGRAMMING VOLTAGE)
C3	CLK (CLOCK SIGNAL)	C7	I/O (DATA INPUT/OUTPUT)
C4	RESERVED TO ISO/IEC JTC 1/SC 17 FOR FUTURE USE	C8	RESERVED TO ISO/IEC JTC 1/SC 17 FOR FUTURE USE

FIG. 1B

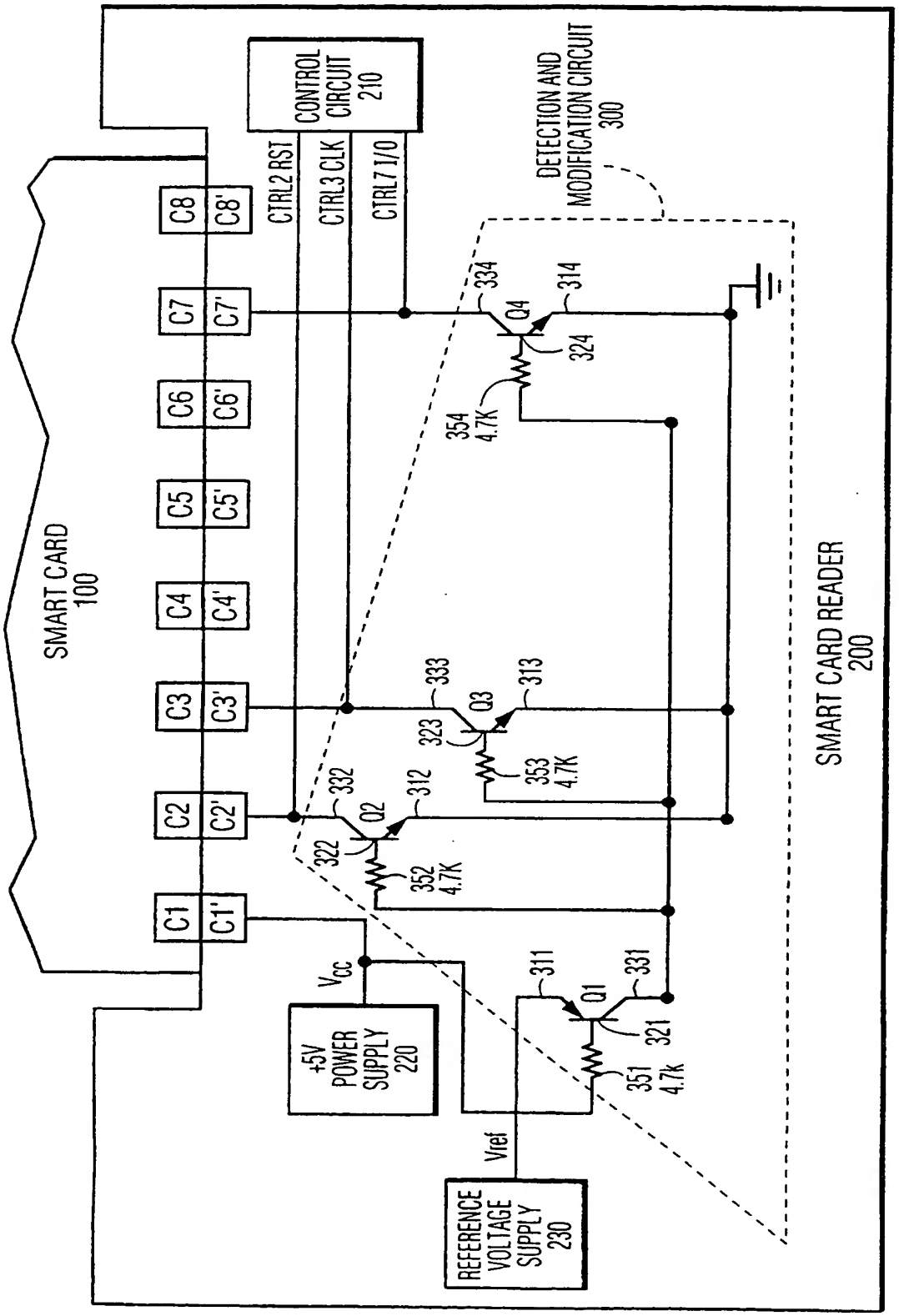

FIG. 2

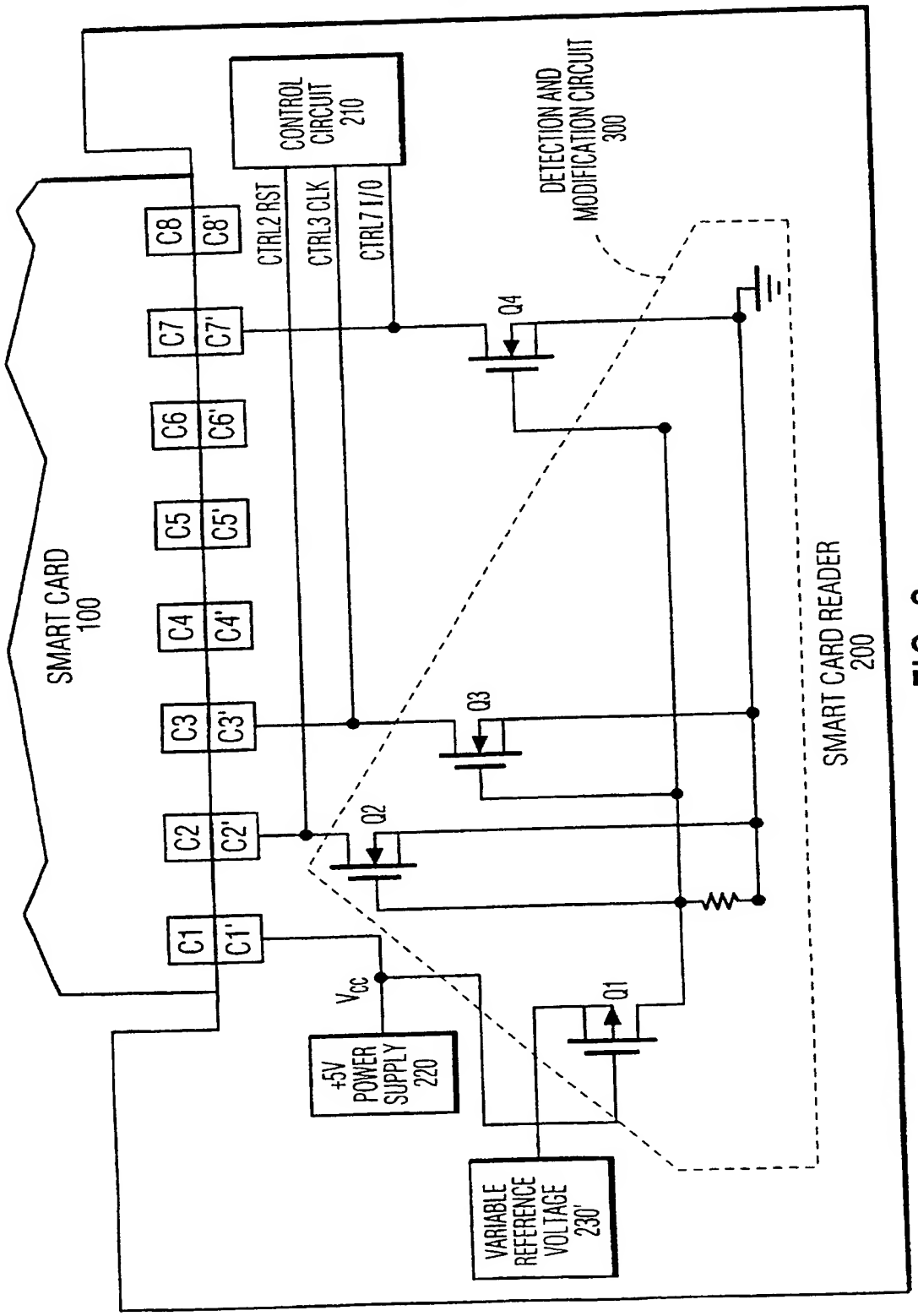
SMART CARD
100
C8
C8'
C7
C7'
C6
C6'
C5
C5'
C4
C4'
C3
C3'
C2
C2'
C1
C1'
CONTROL
CIRCUIT
210
CTRL2 RST
CTRL3 CLK
CTRL7 I/O
DETECTION AND
MODIFICATION CIRCUIT
300
Q4
Q3
Q2
Q1
V_{CC}
+5V
POWER
SUPPLY
220
VARIABLE
REFERENCE
VOLTAGE
230'
SMART CARD READER
200

FIG. 3

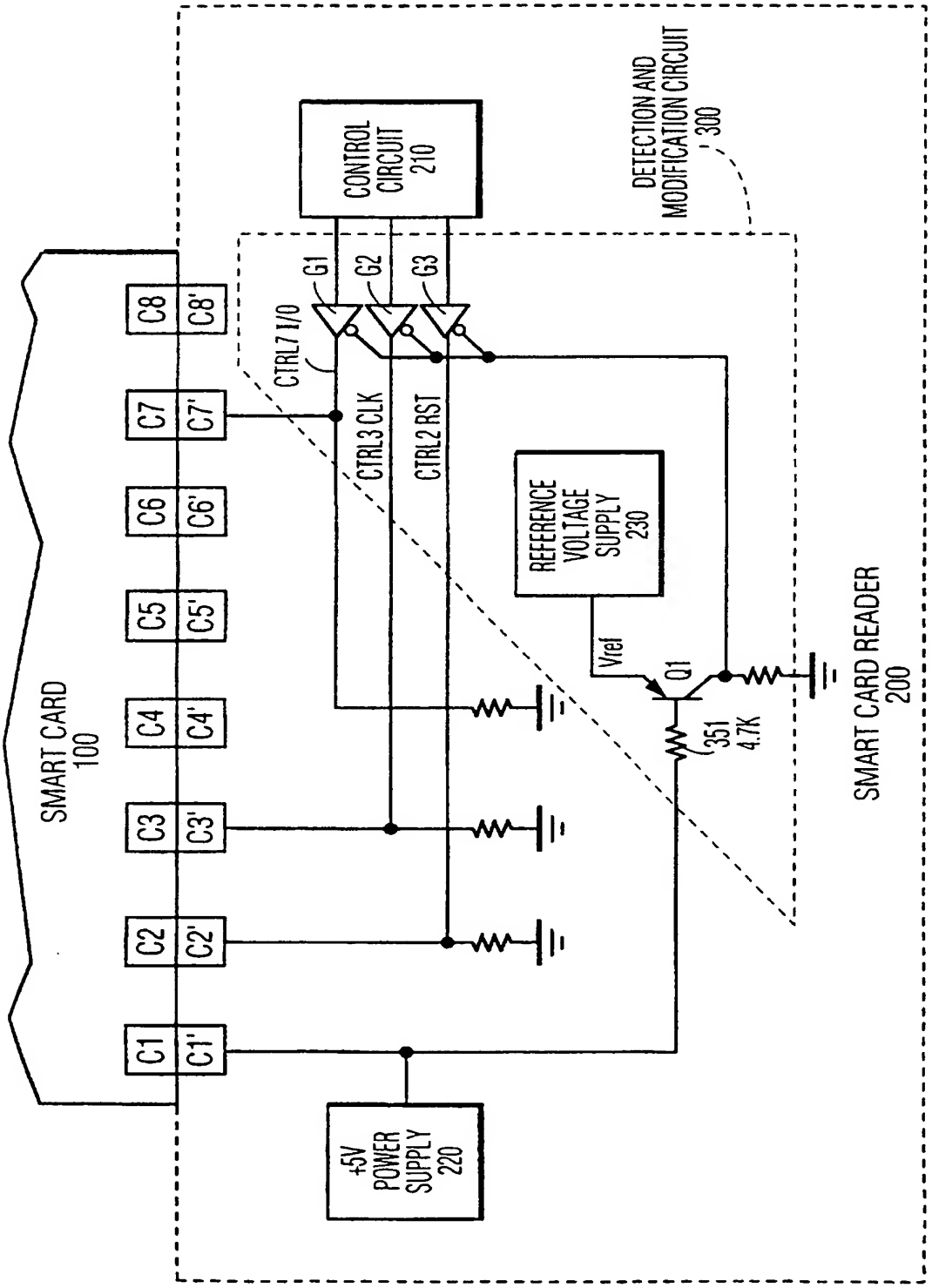

FIG. 4

INTERNATIONAL SEARCH REPORT

Int [redacted] Application No
PCT/US 96/19928

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06K7/00 G06K7/06 G06K19/073

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 April 1997	14.04.97

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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